Assimilation of Microwave Limb Sounder Radiances

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Abstract

It has been shown that the assimilation of limb-sounder data can significantly improve the representation of ozone in NASA's GEOS Data Assimilation Systems (GEOS-DAS), particularly in the stratosphere. The studies conducted so far utilized retrieved data from the MIPAS, POAM, ILAS and EOS Microwave Limb Sounder (EOS MLS) instruments. Direct assimilation of the radiance data can be seen as the natural next step to those studies. The motivation behind working with radiances is twofold. First, retrieval algorithms use a priori data which are either climatological or are obtained from previous analyses. This introduces additional uncertainty and, in some cases, may lead to "self-contamination" when the a priori is taken from the same assimilation system in which subsequently ingests the retrieved observations. Second, radiances can be available in near real time thus providing an opportunity for operational assimilation, which could help improve the use of infrared radiance instruments from operational satellite instruments.

In this presentation we summarize our ongoing work on an implementation of the assimilation of EOS MLS radiances into the GEOS-5 DAS. This work focuses on assimilation of band 7 brightness temperatures which are sensitive to ozone. Our implementation uses the MLS Callable Forward Model developed by the MLS team at NASA JPL as the observation operator. We will describe our approach and recent results which are not yet final. In particular, we will demonstrate that this approach has a potential to improve the vertical structure of ozone in the lower tropical stratosphere as compared with the retrieved MLS product. We will discuss the computational efficiency of this implementation.

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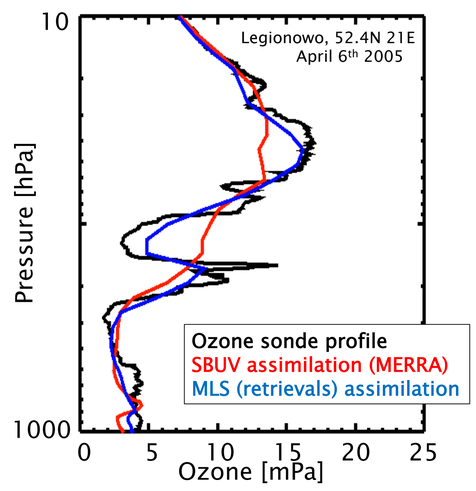
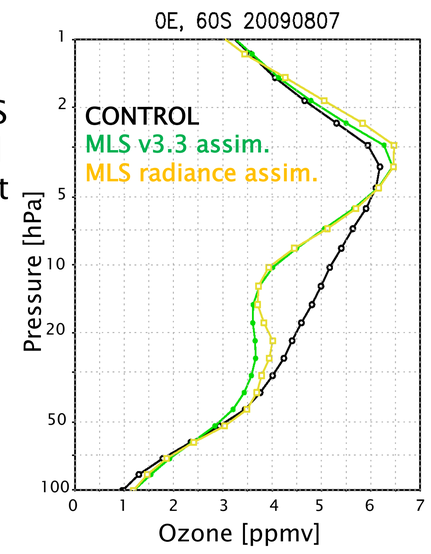
Why Assimilate MLS data?



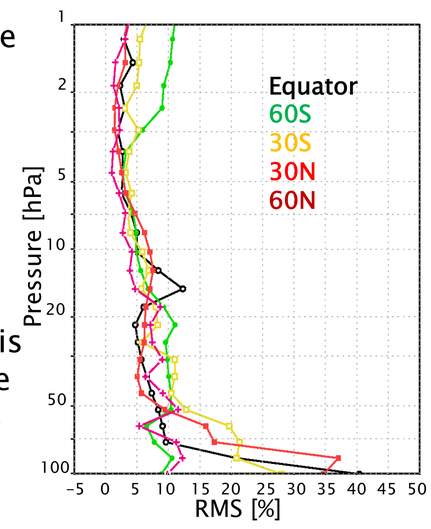
- Ozone: assimilating MLS improves the vertical structures, particularly in the UTLS (above)
- MLS provides global day and night coverage
- Possibility to do it in near real time if either NRT MLS retrievals or MLS radiances are used
- For temperature, assimilating radiances will circumvent the problem of ingesting a priori information (from GEOS-5)

Comparison of assimilated MLS radiances -vs- v3.3 retrievals

Ozone profiles at 60°S and 0°E from a **control experiment** (ozone not assimilated), **assimilation of retrieved ozone** and **assimilation of band 7 radiances**



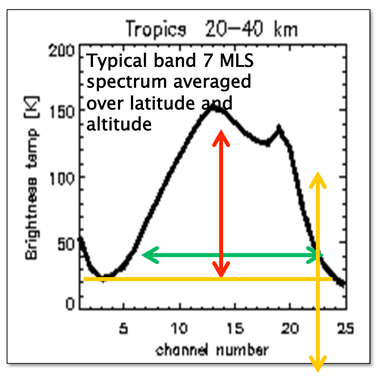
Relative RMS difference between radiance and v3.3-retrieval assimilation averaged at different latitude circles.
Agreement within 5-10% except in the lower stratosphere: this is expected to improve once MLS extinction is fully taken into account.



The Microwave Limb Sounder on EOS Aura

- MLS measures atmospheric limb emission in five spectral regions, centered around 118 GHz, 190 GHz, 240 GHz, 640 GHz, and 2.5 THz.
- The instrument has been operating almost continuously since August 2004.
- Continuous scans from the surface to 90 km are performed every 25 s. Each "profile" consists of scans at 125 tangent altitudes.
- We use 25 channels in band 7 (~240 GHz) which is most sensitive to stratospheric ozone
- We plan to use temperature information from band 1 radiances (~118 GHz)

MLS Radiances: information content



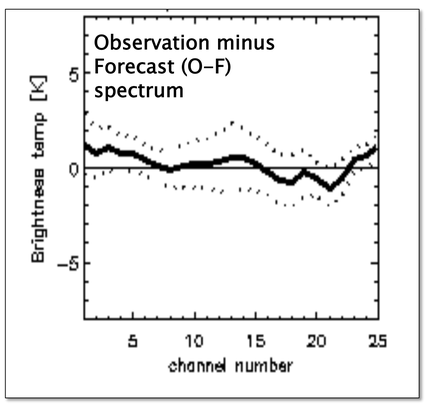
Spectral contrast – sensitive to tracer concentration
Width – depends on tangent pressure
Baseline – "extinction": spectrally flat instrument errors and components not accounted for in the forward model

All three should be retrieved simultaneously

Challenges

- Significant changes in the assimilation code are necessary. The MLS extinction (spectral baseline) and tangent pressure are being added to the GSI control vector
- A very large number of new data may impact the convergence of the minimization algorithm. This will be explored
- In the current configuration the CFM needs ~12 seconds to process a single radiance profile. Further optimization may be needed if MLS radiances are to be used in operational and/or longer research experiments

MLS radiances in the GEOS-5 Atmospheric Data Assimilation System



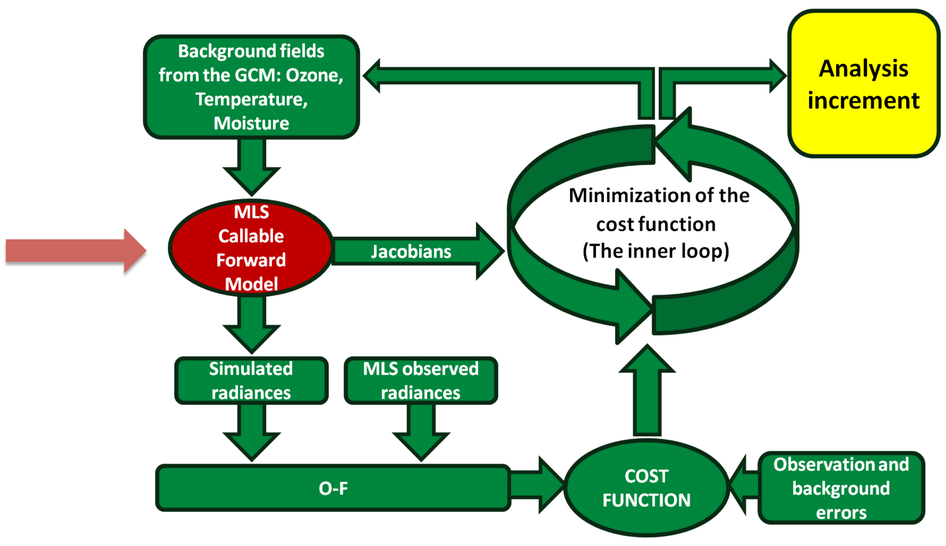
The GEOS-5 ADAS was used in a 2°×2.5°L72 configuration.

MLS radiances are assimilated alongside a full suite of operational data, including "conventional" and nadir-sounding radiances.

The panel (left) shows the O-F of spectral radiances for ozone, averaged between 20-40 km in the Tropics. The dashed line is the 1σ envelope.

Below is a schematic of the MLS radiances inside GEOS-5/GSI

The **MLS Callable Forward Model** (CFM), developed by the MLS team at JPL simulates radiances as they would be measured by MLS given local atmospheric conditions and composition



Summary

- MLS radiances are being implemented in GSI and evaluated in the GEOS-5 ADAS
- Previous work has shown the benefits of assimilating retrieved ozone and temperature from MLS
- Band 7 radiances (sensitive to ozone) have been assimilated; the control vector is being extended to include extinction profiles
- Comparisons with assimilated MLS version 3.3 ozone show good agreement in most of the stratosphere
- The next step is to include a full retrieval of extinction and tangent pressure